REMARKS

Status of the Claims

Claims 1-11 and 13-17 are now present in this application. Claims 1 and 15 are independent.

By this amendment, claim 12 is canceled, claims 16 and 17 are added, and claims 1 and 15 are amended. No new matter is involved.

Basis for the "polymer" language added to claims 1 and 15 is found, for example in the originally filed main body of the specification, paragraph [0025], and in originally filed claim 12, which is part of the specification, as filed.

Basis for the language "subsequently forming a cavity through the micromechanical structure up to the light shaping unit" is found, for example, in the originally filed specification in paragraph [0033] and in the flow chart of Fig. 16. It is clear that firstly, the lens structure is produced (steps 56 and 58), then the micromechanical structure is formed (step 60), and thereafter, the cavity is formed (step 62).

New claims 16 and 17 are clearly supported, for example, in paragraph [0025] of the specification, as originally filed.

Reconsideration of this application, as amended, is respectfully requested.

Rejection Under 35 U.S.C. § 112, 1st Paragraph (Enablement and/or Written Description)

Claims 1-14 stand rejected under 35 U.S.C. § 112, 1st Paragraph. This rejection is respectfully traversed.

The Office Action indicates that the originally filed disclosure does not support a conclusion that the light shaping unit is formed from a layer of non-photoresist material.

Applicants respectfully disagree with this conclusion because if lens unit 12 were made of a photoresist material, it would be removed when the photoresist that was applied over lens material 12 is etched (as disclosed in lines 6-13 on page 4 of the application as originally filed), then the lens material would be removed along with that photoresist material. This specific disclosure clearly supports a conclusion that lens material 12 is not a photoresist material.

Applicants only need one disclosed embodiment to support this claim language, and the original disclosure contains such an embodiment, i.e., where the lens material is not a photoresist

material, at least with respect to the etchant used in the embodiment explained in lines 6-13 of page 4 of this application..

Nevertheless, solely in order to reduce and simplify issues, and expedite prosecution of this application toward allowance, Applicants have canceled claim 12.

Accordingly, reconsideration and withdrawal of this rejection are respectfully requested.

Rejection Under 35 U.S.C. § 112, 2nd Paragraph

Claims 1-15 stand rejected under 35 U.S.C. § 112, 2nd Paragraph. This rejection is respectfully traversed.

The Examiner has set forth certain instances wherein the claim language lacks antecedent basis or is not clearly understood.

In order to overcome this rejection, Applicants have amended claim 1 to correct each of the deficiencies in claim 1 specifically pointed out by the Examiner.

With respect to claims 7 and 8, the Examiner appears to be improperly confusing breadth of claims with definiteness. The Office Action fails to point out why the meaning of "forming" in claims 7 and 8 is unclear or indefinite to one of ordinary skill in the art, which is the standard for whether claims comply with the requirements of 35 U.S.C. § 112, second paragraph.

Instead, the rejection merely states that if the lens acts as an etch stop in claim 8, should not the forming of instant claim 7 be etching.

Applicants do not understand what this has to do with whether one of ordinary skill in the art understands the metes and bounds of the invention. Clearly a step of "forming" reads on a step of "forming by etching" but the Office Action has not cited any statute, Rule of Practice of controlling case law which requires an Applicant to narrow its claims to recite an etching step when the meaning of "forming" is clear and definite.

In this regard, Applicants respectfully submit that the Court of Customs and Patent Appeals, a predecessor to the Court of Appeals for the Federal Circuit, has held "that a claim may be broader than the specific embodiment disclosed in a specification is in itself of no moment." *In re Rasmussen,* 650 F.2d 1212, 1215, 211 USPQ 323, 326 (CCPA 1981). This case was cited in *Ralston Purina Company v. Far-Mar-Co., Inc.*, 227 USPQ 177 (Fed. Cir. 1985), which indicated that the open ended range claims of U.S. Patent No. 3,940,495 were proper and

were supported by the description of a parent application. Additionally, the Court of Customs and Patent Appeals stated, in *In re Smythe and Shamos,* 178 USPQ 279 (CCPA 1073) that mere omission of claim limitations does not suggest omission of steps or part.

Accordingly, reconsideration and withdrawal of this rejection are respectfully requested.

Rejection Under 35 U.S.C. § 102

Claims 1, 2 and 5-15 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Sun et al. ("Sun"). This rejection is respectfully traversed.

A complete discussion of the Examiner's rejection is set forth in the Office Action, and is not being repeated here.

Claim 1, as amended, recites a method of producing a compact movable structure for a light shaping unit comprising the steps of: forming a light shaping unit from a polymer material provided on a carrier of another material; and subsequently forming, from said carrier, an intermediate micromechanical plate between side plates of a micromechanical structure for movably supporting the light shaping unit in the micromechanical structure, and subsequently forming a cavity through the micromechanical structure up to the light shaping unit.

Support for the "forming a light shaping unit from a polymer material" feature is found, for example, on page 3, last paragraph, of the application as filed, as well as in original claim 12.

Support for the language "subsequently forming a cavity through the micromechanical structure up to the light shaping unit" is found, for example, in the first full paragraph on page 5 of the application as filed, and in the flow chart of Fig. 16. It is clear from this paragraph and Fig. 16, that first, the lens is produced in step 56 and 58, and then the micromechanical structure is formed by step 60, and thereafter the cavity is formed in step 62.

Claim 15 recites a method of producing a compact movable structure for a light shaping unit, comprising: forming a light shaping unit from a material provided on a carrier of another material; and subsequently forming a micromechanical plate from the carrier as part of a micromechanical structure for movably supporting the light shaping unit, wherein the micromechanical plate directly supports the light shaping unit, and subsequently forming a cavity through the micromechanical structure to the light shaping unit.

Turning to the merits of the rejection of claim 1, Applicants respectfully disagree with the Office's interpretation of Sun's relied upon embodiment found in col. 3, lines 26-33. In col. 3, lines 22-33, it appears to Applicants that Sun first etches its substrate to form cavity 15, which stops at the SiO2 etch stop layer 74. Then a circular hole is formed in the top by etching away region 13 of Si layer 76. It is not until after these steps are accomplished that a photoresist microlens is formed over etched-away region 13 of Si layer 76. Lastly, the comb drive structure of the stage is etched away.

Thus, Sun forms the cavity before forming the lens and an intermediate stage. In other words, Sun does not disclose that the light shaping unit is formed before the forming of a cavity through the micromechanical structure, and fails to disclose that the light shaping unit is made of a polymer. Accordingly, Sun does not anticipate claim 1.

With respect to claim 15, Sun's micromechanical plate cavity is clearly formed prior to the forming of the light shaping unit (microlens). Accordingly, Sun does not anticipate claim 15.

Applicants respectfully submit that Sun represents technology that has a more complicated production of its light shaping unit on a micromechanical structure compared with the claimed invention, and includes problems discussed, for example, on page 1, line 39 – page 2, line 3, of Applicants' specification.

In Applicants' claimed invention, a compact movable structure is produced for a light shaping unit comprising the steps of: forming a light shaping unit from a material provided on a carrier of a first material, and forming a micromechanical structure from the carrier in a second, different material, wherein the forming of the light shaping unit is performed before the forming of the micromechanical structure.

This differs from the disclosure of the Sun document, wherein the microlens is preferably Si-based, see column 1, lines 51-53. The micro lens shutter is also Si-based, see column 3, lines 5-7. Thus the micro lens is fabricated by melting a photo resist pedestal deposited on a silica substrate, see column 3, lines 8-9. Alternatively, the microlens is fabricated by bonding a SiO2 and a SOI wafer, see column 3, line 21.

Thus, the microlens is formed from a Si-based material, as is its micromechanical structure.

According to the present invention however, the lens 12 is formed of a polymer material, which is a different material than the micromechanical structure 14, 16, 18, 22, 28, 29, see page

3, lines 34-42, in the sense that the lens 12 is formed, for example, using a polymer such as e.g. CYTOP or Parylene, while the micromechanical structure 14, 16, 18, 22, 28, 29 is formed out of a silicon layer 44 and a resist layer 42. Sun, on the other hand, does not disclose the use of such different materials for its light shaping unit and for its micromechanical structure.

By using different materials for the light shaping unit 12 and the micromechanical structure 14, 16, 18, 22, 28, 29, these features can be optimised for best performance considering the optical properties and robustness of the mechanics, respectively, as explained, for example on page 7, lines 13-15.

Through the production method according to the invention, where the forming of the light shaping unit 12 in a first material takes place before the forming of the micromechanical structure 14, 16, 18, 22, 28, 29 in a second, different material comprising a cavity, it is possible to form a light shaping unit 12 with an underlying micromechanical structure 14, 16, 18, 22, 28, 29 in a simple way and that does not have any difficult compatibility requirements between forming of micromechanics 14, 16, 18, 22, 28, 29 and forming of light shaping unit 12.

Moreover, by making the lens and the micromechanical structure 14, 16, 18, 22, 28, 29 before making the cavity through the micromechanical structure 14, 16, 18, 22, 28, 29, one avoids weakening the sensitive micromechanical structure 14, 16, 18, 22, 28, 29 during the production. Additionally, expensive later mounting of individual elements in the light shaping unit 12 is also avoided, as explained, for example, on page 7, lines 6-11.

The claimed invention therefore provides a simplified production method of delicate material by firstly producing the lens and then producing the micromechanical structure for moving the lens, and the cavity for letting through the light.

Typically, prior art devices and methods such as the ones disclosed in Sun, wherein the lens and the micromechanical structure are made out of the same material; provide a compromise between the optical properties, mechanical properties and costs. Sun leads one of ordinary skill in the art away from the claimed invention by stipulating that the microlens and the micromechanical structure is formed <u>after</u> having firstly made a cavity through the carrier, see column 3, lines 26-31. Because Sun's cavity is made before its lens is fabricated, Sun not only does not disclose the claimed invention but, also, cannot possibly render obvious the claimed invention.

Sun differs from the claimed invention, in that, in the claimed invention the lens and the micromechanical structure are formed while the substrate is strong. By the present production method, the tedious work of placing a separately produced lens inside a fragile, separately produced micromechanical the structure is omitted. Thus, mass production of light shaping units through embossing is facilitated.

Further, by forming an opening/cavity from the bottom of the carrier in a direction towards the light shaping unit in order to provide a light passage channel, wherein the light shaping unit serves as an etch stop in the forming of the opening, mass production of light shaping units is further simplified and improved.

Moreover, claim 8 recites that the light shaping unit serves as an etch stop in the forming of the opening. This feature is not disclosed by Sun. According to Sun, its microlens is formed using a silicon based material, i.e., the same material as the micromechanical structure and, thus, the Office Action does not explain how the same material can be used as an etch stop. In this regard, Applicants respectfully submit that Sun's microlens is preferably Si- based (see col. 1, lines 51-53), and its microlens shutter is also Si-based (see col. 3, lines 5-7). Therefore, Sun's microlens is fabricated by melting a photoresist pedestal deposited on a silica substrate (see col. 3, lines 8-9). Alternatively, Sun's microlens is fabricated by bonding a SiO_2 and a SOI wafer (see col. 3, line 21).

Consequently, Applicants do not understand how Sun's light shaping unit can serve as an etch stop in the forming of the opening, and because of this, Sun is not able to avail itself of further simplification and improvement of the mass production of light shaping units, as is done in Applicants' claimed invention.

Accordingly, reconsideration and withdrawal of this rejection are respectfully requested.

Rejections under 35 U.S.C. § 103

Claims 1-14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Sun et al. in view of Japanese document 2000-155201 A. This rejection is respectfully traversed.

A complete discussion of the Examiner's rejection is set forth in the Office Action, and is not being repeated here.

Initially, Applicants respectfully submit that Sun does not disclose the invention recited in claims 1-14 for reasons presented above.

The Office Action turns to JP 2000-155201 A, which discloses a lens array substrate used with a reflection type image display device. The reflection image display device is shown, for example, in Fig. 9, and includes microlens array 4 on microlens array substrate 1. A copy of a computer generated English language translation of JP 2000-155201 A, downloaded from the JPO website, is attached for the convenience of the Examiner, in this regard.

It is clear from JP 2000-155201 A that its microlens array does not involve mounting its microlenses on a movable structure, but is simply a passive optical device in which its microlens array lenses are stationary, and do not move.

Thus, JP-2000-155201 A is not relevant to the claimed invention, which positively recites a compact movable structure of a light shaping unit, and the Office Action does not provide objective evidence that one of ordinary skill in the art would turn to JP 2000-155201 A to modify Sun's manufacturing process.

Moreover, the Office Action fails to explain why one of ordinary skill in the art would be properly motivated to destroy Sun's fundamentally different method of making its electro-actuated microlens assemblies when neither Sun nor JP 2000-155201 A contain any hint of doing so. Another way of stating this is that because neither applied reference discloses the claimed method, there is no logical basis on which to conclude that those fundamentally deficient reference disclosures provide the basis for features totally missing from both references.

Accordingly, reconsideration and withdrawal of this rejection are respectfully requested.

New Claims

Claims 16 and 17 are added. Applicants respectfully submit that these claims patentably define over the applied art at least because they depend from claim 1, which patentably defines over the applied art for reasons discussed above, and because of the additional features recited in these claims.

Consideration and allowance of claims 16 and 17 are respectfully requested.

Conclusion

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

In view of the above amendment, Applicants believe the pending application is in condition for allowance.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Robert J. Webster, Registration No. 46472 at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: October 29, 2010

Respectfully submitted,

By

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Attachment: English translation of JP 2000-155201 A

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]A lens array substrate, wherein a focal position of each of said lens is in a lens array substrate which arranged two or more lenses on a flat surface which is not parallel to a substrates face, or a curved surface.
[Claim 2]A lens array substrate, wherein curvature of at least some lenses differs from curvature of other lenses among said each lens in a lens array substrate which arranged two or more lenses.
[Claim 3]The lens array substrate according to claim 1 or 2, wherein said lens equips the light entering surface with an antireflection film.
[Claim 4]Have two or more lens reversal patterns, and put and carry out die pressing of the unhardened energy hardening resin between a die and a substrate which differ in curvature of at least some lens reversal patterns from curvature of other lens reversal patterns, and it is made it, A manufacturing method of a lens array substrate stiffening the resin concerned by carrying out the energy hardening reaction of the resin concerned.
[Claim 5]A reflection type picture display device provided with a type image display device which reflects incident light selectively for every pixel, and the lens array substrate according to claim 1, 2, or 3 which arranged two or more lenses corresponding to said each pixel.
[Claim 6]The reflection type picture display device according to claim 5, wherein said type image display device and said lens array substrate are not parallel.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to a lens array substrate, its manufacturing method, and a reflection type picture display device. It is related with the reflection type picture display device using the microlens array substrate which arranged the lens of an especially different focal distance, and its manufacturing method and microlens substrate concerned.
[0002]
[Description of the Prior Art]If shown in the conventional reflection type picture display device, the microlens array which consists of arrangement of two or more detailed lenses as a lens for condensing light for every pixel is used. This microlens array is formed in the microlens array substrate. Based on drawing 16, the structure of the conventional microlens array substrate 40 is explained. The microlens array substrate 40 comprises being filled up with the high refractive index resin 43 in the crevice etched into the lens substrate 41 which consists of glass thin sheets. The microlens array 42 is formed in the interface of this lens substrate 41 and high refractive index resin 43 with two or more lens patterns 42a. All of each lens diameter and curvature of the lens pattern 42a are the same.
[0003](Manufacturing method of the conventional microlens array substrate) The conventional manufacturing method of the above-mentioned microlens array substrate 40 is explained based on drawing 17. First, the lens substrate 41 of predetermined thickness as shown in drawing 17 (a) is prepared, and the mask 45 which was able to open the opening 44 in the same pitch as the lens pattern 42a is formed in the surface of the lens substrate 41 like drawing 17 (b). Subsequently, as shown in drawing 17 (c), the lens pattern 42a is formed in a concave by performing isotropic etching processing on the surface of the lens substrate 41 through the opening 44 of the mask 45. And after removing the mask 45, the crevice of the above-mentioned lens pattern 42a is filled up with the high refractive index resin 43 like drawing 17 (d), respectively, and the microlens array 42 is formed with the lens pattern 42a in the interface of the lens substrate 41 and the high refractive index resin 43.
[0004]All the focal distances of each lens of the microlens array substrate 40 obtained by the above-mentioned method are equals. This is because uniform isotropic etching processing is made over the lens substrate 41 whole surface, so all the curvature of each lens obtained becomes the same.
[0005]Then, for the purpose of the artificers of this invention changing the curvature of each lens arbitrarily, Each lens pattern 46a and 46b and the method of forming -- were tried carrying out an etching process independently about every [a single tier], and making the time increase one by one about every one lens like drawing 18 (a) - drawing 19 (f). In this method, the lens pattern 46a is formed by forming in the surface of the lens substrate 41 of drawing 18 (a) the mask 45 which has the one opening 44, and etching the lens substrate 41 through [drawing 18 (b)] and this opening 44 [drawing 18 (c)]. After removing the first mask 45, form in the surface of the lens substrate 41 the

mask 45 which opened the opening 44 in the position which adjoins the lens pattern 46a, and Subsequently, [drawing 18 (d)], By etching the lens substrate 41 through this opening 44, the lens pattern 46b in which the depth differs in the position which adjoins the lens pattern 46a is formed [drawing 18 (e)]. After forming in the surface of the lens substrate 41 many lens patterns 46a and 46b in which the depth differs by repeating such a process, and --, as it is filled up with the high refractive index resin 43 in the lens patterns 46a and 46b and -- and is shown in drawing 18 (f), the microlens array substrate 40 is obtained.

[0006]However, also in the method of adjusting etching time individually for every lens in this way, curvature of each lens could not be arbitrarily changed into each lens patterns 46a and 46b and every --, but the curvature of all the lenses was almost constant. And in this method, it was not able to avoid that each lens diameter was expanded one by one with the increase in etching time like drawing 19 (f). When using a microlens array with an image display device, in order to coincide the center of each lens with the center of each pixel, the path of each lens must be made equal, In order to obtain uniform resolution and to have to make the path of each lens equal, it turned out that the microlens array 46 which has a different lens diameter for such every lens cannot be used.

[0007]On the other hand, there is a device of composition of being shown in drawing 20 as a conventional reflection type picture display device. The white light W reflected in this reflection type picture display device 50 with the white light W irradiated from the white light source 51 and the spherical mirror 52 is condensed by the condenser 53, By rotating the disc-like color filter plate 54 which has the red stationed so that it may pass through near the focus of the condenser 53, and a blue and green filter, red (R), After a spectrum is carried out to the light flux of green (G) blue (B) in time sharing, it is changed into a parallel beam by the lens 55, and glares toward the digital mirror devices (it outlines the following DMD) 56 with it. The red who DMD56 arranged the detailed micro mirror corresponding to each pixel, and entered into DMD56, and each green and blue light flux, By the micro mirror of DMD56 operated synchronizing with rotation of the color filter plate 54, the light flux which light flux required for image display does not need for image display is reflected by the projection lens 57 towards the optical absorber 59. Then, light flux required for image display serves as a picture projected and expanded towards the screen 58 with the projection lens 57. On the other hand, the light flux which is not required for image display is absorbed, without being scattered about by the optical absorber 59.

[0008]

[Problem(s) to be Solved by the Invention]However, in the conventional microlens array substrate. All the focal distances of each lens which constitutes a microlens array were the same, and since it was individually unchangeable for every lens, the focal position of each lens became a microlens array and parallel, and was not able to be formed on the flat surface parallel to DMD.

[0009]In the method which controls the reflecting direction of the parallel beam by the micro mirror of DMD arranged by matrix form like the conventional reflection type picture display device. Since the parallel beam was able to advance also into the crevice between adjacent micro mirrors and was not able to reflect a parallel beam 100% by DMD, its utilization efficiency of light was bad and it had become a cause by which a picture became dark. After a part of parallel beam which advanced into the crevice between micro mirrors carried out scattered reflection within said crevice, the problem which soils the projection picture on a screen also had it by carrying out the stray light in the direction of a projection lens.

[0010]There is a place which it is made in order that this invention may solve an above-mentioned technical consideration, and is made into the purpose in being able to manufacture easily the lens array from which a focal distance differs for every lens, and a display providing cheaply a bright clear reflection type picture display device by said lens array.

[0011]

[Description of the Invention]In the lens array substrate which arranged two or more lenses, the lens array substrate according to claim 1 has a focal position of each of said lens on the flat surface

which is not parallel to a substrates face, or a curved surface.
[0012]Although the field containing the focus of each lens was restricted to the thing in a field parallel to a substrates face in the conventional lens array substrate, in the lens substrate of this invention, the field containing the focus of each lens can be designed freely, and the image formation face etc. could be designed arbitrarily.
[0013]In the lens array substrate which arranged two or more lenses, the lens array substrate according to claim 2 differs from the curvature of the lens of others [curvature / of at least some lenses] among said each lens.
[0014]Although the conventional lens array substrate had the same curvature of all the lenses, it can change a focal distance for every lens in the lens array substrate of this invention. Therefore, also by this lens array substrate, the field containing the focus of each lens can be designed freely, and an image formation face etc. can be arbitrarily designed now.
[0015]The lens formed of the interface between two sorts of transparent resin in which refractive indicees differ may be sufficient as Claim 1 or the lens array substrate of 2, and the lens formed of the surface (interface of resin and air) of resin may be sufficient as it.
[0016]In the lens array substrate according to claim 1 or 2, as for the embodiment according to claim 3, said lens equips the light entering surface with the antireflection film.
[0017]According to the embodiment according to claim 3, reflection of the light which enters into a lens array substrate with an antireflection film can be prevented, and the utilization efficiency of light can be raised.
[0018]The manufacturing method of the lens array substrate according to claim 4, Have two or more lens reversal patterns, and put and carry out die pressing of the unhardened energy hardening resin between the die and substrate which differ in the curvature of at least some lens reversal patterns from the curvature of other lens reversal patterns, and it is made it, It is characterized by stiffening the resin concerned by carrying out the energy hardening reaction of the resin concerned. Here, energy hardening resin is visible light hardening resin, infrared hardening resin, electron beam hardening resin, heat-hardened type resin, moisture curing type resin, etc.
[0019]According to the manufacturing method of the lens array substrate according to claim 4, the lens array substrate provided with the lens with which curvature differs by the mold aggressiveness by a die can be easily mass-produced by forming the lens reversal pattern in which curvature differs in a die.
[0020]The reflection type picture display device according to claim 5 is provided with the type image display device which reflects incident light selectively for every pixel, and the lens array substrate according to claim 1, 2, or 3 which arranged two or more lenses corresponding to said each pixel.
[0021]According to the reflection type picture display device according to claim 5, a parallel beam can be made to be able to condense by a lens array substrate, and each pixel of a type image display device can be made to condense by using said lens array substrate and said type image display device. Therefore, the light which enters out of each pixel can be decreased, or can be lost, the utilization efficiency of light can be raised, and a bright display image can be obtained. Since the stray light by reflection of the light which entered out of the pixel is also lost, a blot of a picture etc. can be made small.
[0022]In a reflection type image display device, since a microlens array and the type image display device are not parallel, when reflecting by a type image display device, for every picture element position, the light path length from the condensing position of each beam of light to a screen differs, and image formation of the whole picture is not carried out to a screen. However, in the image display device of this invention, since a focal distance can be changed for every lens corresponding to each pixel, light path length to the condensing position and screen of light who enters into each pixel can be made uniform, and it becomes possible to acquire a clear picture.
[0023]The embodiment according to claim 6 is characterized by said type image display device and said lens array substrate not being parallel in the image display device according to claim 5.

[0024]Since the light which penetrated the lens array substrate can be made to condense on arbitrary fields in the image display device of this invention, A picture can be made to project on a screen etc., without being able to acquire a clear picture now in a reflection type picture display device, and being barred by the lens array substrate, even if it arranges a lens array substrate and a type image display device to non parallel as mentioned above.

[0025]

[Embodiment of the Invention](A 1st embodiment) Drawing 1 shows the structure of the microlens array substrate 1 by this invention, and the structure is as follows. This microlens array substrate 1 puts the two-layer transparent lens resin layers 6 and 8 from which a refractive index differs between the base glass board 2 and the cover glass board 3, The interface of the lens resin layers 6 and 8 is formed in the arrangement of the lens patterns 4a and 4b and -- which have different curvature, and the microlens array 4 is formed of said lens patterns 4a and 4b and --. It is possible by changing the curvature of said lens patterns 4a and 4b and each lens of -- to change the focal distance of each lens individually and to arrange a focus on the flat surface set up beforehand or a curved surface. The lens resin layer 6 and the lens resin layer 8 are protected from the structure where the base glass board 2 and the cover glass board 3 are arranged on the outside of the lens resin layer 6 and the lens resin layer 8 by said base glass board 2 and the cover glass board 3.

[0026]The details of (the manufacturing method of the microlens array substrate of this invention), next the manufacturing method of the microlens array substrate 1 of this invention are explained below. This is the method of forming the microlens array substrate 1 by producing original recording by performing laser processing to a glass substrate, producing a nickel master and La Stampa one by one with nickel electroforming from said original recording, and pressing and stiffening unhardened resin by said La Stampa.

[0027]First, the manufacturing method of La Stampa used as the duplicate of the original recording of the microlens array 4 is explained, referring to drawing 2. First, as the plate-like glass plate 10 as shown in drawing 2 (a) is prepared and it is shown in drawing 3, on the surface of the glass plate 10. It irradiates with the laser beam which made it condense with the image formation lens 11, evaporative removal of the glass plate 10 is carried out to the shape shown by a two-dot chain line with laser processing (laser lithography), and the desired uneven patterns 12a and 12b and -- are formed in the surface of the glass plate 10 [drawing 2 (b)]. Here, the above-mentioned uneven patterns 12a and 12b and -- are the same as that of the shape of the lens side of the microlens array 4 which changed the curvature of each lens side individually, in order to double the focal position of each lens on arbitrary flat surfaces or a curved surface. Said laser processing is performed using the laser beam machining device currently controlled by the computer, and if the formed data is inputted even if it is precise and complicated shape, it is easily processible.

[0028]Thus, after producing the original recording 13 which forms the uneven patterns 12a and 12b and -- in the surface of the glass plate 10, and consists of the glass plate 10, Nickel is made to deposit on the original recording 13, the nickel master 14 which is inverted shapes of the original recording 13 is produced with nickel electroforming, and [drawing 2 (c)] and the nickel master 14 are exfoliated from the original recording 13 [drawing 2 (d)]. When producing the nickel master 14 with nickel electroforming, as the preparation, the surface of the original recording 13 which electric-conduction-izes by vacuum deposition or an electroless deposition method, and was electric-conduction-ized is used as the negative pole, for example, electroplating of the original recording 13 is carried out by a nickel sulfamate bath, and the nickel master 14 is produced.

[0029]What reproduced this nickel master 14 with nickel electroforming further is made into La Stampa 15 (duplicate of the original recording 13). In reproducing the nickel master 14, after making an oxide film from a potassium dichromate solution, it produces La Stampa 15 which the uneven pattern reversed again with nickel electroforming on the surface of the nickel master 14 [drawing 2 (e)]. In this way, said uneven patterns 12a and 12b, the same reversal patterns 17a and 17b as --, and -- are formed in La Stampa 15.

[0030]As the another method of producing La Stampa 15, as shown in drawing 4 (a) - (e), the original recording 13 may be produced by carrying out laser processing of the resist 16 applied to the surface of the glass plate 10. In using the resist 16, as the glass plate 10 and an adherence agent of the resist 16, For example, the silane coupling agent is applied to the surface of the glass plate 10, and after carrying out laser processing, the uneven pattern 12 of the request by the resist 16 is formed in the surface of the glass plate 10 through the process of exposure, development, and washing [drawing 4 (a) and (b)]. Laser processing is performed like drawing 3 and the uneven patterns 12a and 12b of the request which changed the curvature of each lens individually, and -- are formed. Next processing is performed like below drawing 2 (c) [drawing 4 (c) - (e)].

[0031]Below, drawing 5 (a) - drawing 6 (f) explain the manufacturing method of the microlens array substrate 1 which used above-mentioned La Stampa 15. This is the method of fabricating the microlens array 4 between the base glass board 2 and the cover glass 3 by what is called 2P (Photo-Polymerization) law using the ultraviolet curing type resin hardened by UV irradiation.

[0032]First, as shown in drawing 5 (a), after supplying the liquid transparent ultraviolet curing type resin 5 on the transparent base glass board 2, La Stampa 15 is dropped towards the base glass board 2 from on the ultraviolet curing type resin 5. Said reversal patterns 17a and 17b and -- are formed in the undersurface of this La Stampa 15. Fully force this La Stampa 15 on the base glass board 2, and the ultraviolet curing type resin 5 is put between La Stampa 15 and the base glass board 2, After extending the ultraviolet curing type resin 5 between La Stampa 15 and the base glass board 2, carrying out die pressing of the ultraviolet curing type resin 5 and carrying out it by the reversal patterns 17a and 17b of La Stampa 15, and --, A state as it is is held and the ultraviolet curing type resin 5 is irradiated with ultraviolet rays (UV light) with an ultraviolet ray lamp etc. through the base glass board 2 [drawing 5 (b)].

[0033]Since a hardening reaction will be caused and hardened if the ultraviolet curing type resin 5 which has irradiated with ultraviolet rays is exposed to ultraviolet rays, the transfer form of the reversal patterns 17a and 17b of La Stampa 15 and -- is carried out to the ultraviolet curing type resin 5. If La Stampa 15 is raised and it dissociates from the ultraviolet curing type resin 5, The lens resin layer 6 is fabricated on the base glass board 2 with the hardened ultraviolet curing type resin 5, and the lens patterns 4a and 4b and the pattern of the microlens array 4 which consists of -- are fabricated by the surface of the lens resin layer 6 concerned [drawing 5 (c)]. The ultraviolet curing type resin 5 has a uniform refractive index over the lens resin layer 6 whole region.

[0034]An antireflection film is formed in the light entering surface of the base glass board 2 in sputtering (not shown). With the above-mentioned antireflection film, reflection of the light which enters into a lens can be prevented and the utilization efficiency of light can be raised. And on the hardened lens resin layer 6, in the lens resin layer 6, after supplying the transparent ultraviolet curing type resin 7 which differs in a refractive index and is liquid, the cover glass board 3 is straightly dropped towards the lens resin layer 6 from on the ultraviolet curing type resin 7 [drawing 6 (d)]. Fully push this cover glass board 3 against the lens resin layer 6, and the ultraviolet curing type resin 7 is put between the cover glass board 3 and the lens resin layer 6, After accustoming the surface of the ultraviolet curing type resin 7 level with the cover glass board 3 and extending the ultraviolet curing type resin 7 between the cover glass board 3 and the lens resin layer 6, A state as it is is held and the ultraviolet curing type resin 7 is irradiated with ultraviolet rays (UV light) with an ultraviolet ray lamp etc. through the base glass board 2 and the lens resin layer 6 [drawing 6 (e)].

[0035]The ultraviolet curing type resin 7 which has irradiated with ultraviolet rays will cause and harden a hardening reaction, if exposed to ultraviolet rays. As a result, the lens resin layer 8 is fabricated between the lens resin layer 6 and the cover glass board 3 with the ultraviolet curing type resin 7, and the microlens array 4 is fabricated by the interface of the lens resin layer 6 and the lens resin layer 8 [drawing 6 (f)]. The ultraviolet curing type resin 7 has a uniform refractive index over the lens resin layer 8 whole region.

[0036]Thus, if even La Stampa 15 used as a mold is produced, the 2P method by La Stampa 15 after that, Since the microlens array substrate 1 can be obtained if dropping of the ultraviolet curing type resin 5 and 7, press, and hardening are repeated, the microlens array substrate 1 can be easily manufactured by a small man day.
[0037]If the microlens array substrate 1 is produced by the 2P method, a focal distance differs from curvature for every lens, and a microlens array substrate with a uniform lens diameter can be manufactured easily.
[0038]Here, although the ultraviolet curing type resin 5 and 7 was used as resin, what is necessary is just energy hardening resin which restriction in particular will not have on the function which forms a lens if a refractive index is fitness, and hardens from an uncured state, and has translucency. As an example of such energy hardening resin, there are visible light hardening resin, infrared hardening resin, electron beam hardening resin, heat-hardened type resin, moisture curing type resin, etc.
[0039]According to arrangement of the micro mirror of DMD26, the lens array of the microlens array 4 like drawing 7, It may be the cylindrical lens array which could arrange the lens of the right hexagon in the shape of [of the bee] a nest, and arranged the rectangular lens to stripe shape like drawing 8.
[0040](Reflection type picture display device of this invention) Drawing 9 is an outline lineblock diagram of the reflection type picture display device 20 by one embodiment of this invention. the light source part which consists of the white light source 21, the spherical mirror 22, and the condensing lens 23, and the spectrum which consists of the dichroic mirrors 24R, 24G, and 24B and the microlens array 4 -- it comprises a part and an indicator which consists of DMD26, the projection lens 27, and the optical absorber 29. Here, the above-mentioned microlens array 4 is constituted in the microlens array substrate 1, and is the above-mentioned microlens array. In order to display a picture symmetrically in drawing 9, DMD26, the projection lens 27, and the screen 28 of each other are arranged in parallel.
[0041]Next, order is explained later on about operation of each part of the reflection type picture display device 20 of drawing 9. First, the white light W reflected with the white light W irradiated from the white light source 21 and the spherical mirror 22 enters into the dichroic mirrors 24R, 24G, and 24B, after being changed into a parallel beam by the condensing lens 23.
[0042]The dichroic mirrors 24R, 24G, and 24B shift only the angle theta sequentially from the side near the white light source 2, respectively, and the dichroic mirrors 24R, 24G, and 24B of three sheets are arranged at fanning, as the light of red and a green and blue wavelength band is reflected, respectively and it is shown in drawing 10. The white light W which carried out the deer and entered into the dichroic mirrors 24R, 24G, and 24B of three sheets. ** Pass the red beam of light reflected with the dichroic mirror 24R, and the ** dichroic mirror 24R, The green beam of light produced by being reflected with the dichroic mirror 24G and passing the dichroic mirror 24R again, ** The dichroic mirrors 24R and 24G are passed, and it is reflected with the dichroic mirror 24B, and is divided into 3 of the blue beam of light produced by passing the dichroic mirrors 24G and 24R again beams of light. At this time, to a red beam of light, only the angle of 2 theta inclines, a direction of movement emits a green beam of light, to a green beam of light, a direction of movement inclines only the angle of 2 theta, and a blue beam of light is emitted (drawing 10).
[0043]The red and each green and blue parallel beam which were divided with the dichroic mirrors 24R, 24G, and 24B, It enters at the angle leaning [2theta every] to the microlens array 4 concerning this invention, respectively, For every lens of the microlens array 4, it is condensed as red and green and blue light flux, respectively, and it glares to the micro mirror side of DMD26, emitting slightly, once converging with each focus (refer to drawing 12 and drawing 13).
[0044]Here, DMD26 is the optical element which made many detailed micro mirrors 32 arrange on Si substrate 31 by using micro-machining art. The structure for 1 pixel of this DMD is shown in drawing 11. The supporter 33 of the couple is formed in the upper surface of Si substrate 31, and

the both ends of the torsion hinge 34 are supported by the supporter 33 in the surface of Si substrate 31. The center section of the yoke 35 is attached to the torsion hinge 34, and the micro mirror 32 is formed in the upper bed of the pillar section 36 stood to the center of the yoke 35. the upper surface of Si substrate 31 -- electrical and electric equipment, such as static electricity, -- the mirror driving means (not shown) for controlling the angle of the micro mirror 32 is established by adjusting inclination of the yoke 35, exerting driving force on the yoke 35 and twisting the torsion hinge 34 with magnetic power. In this way, if the angle of the micro mirror 32 can be changed to a 2-way and the micro mirror 32 is irradiated by leaning the yoke 35, the direction of catoptric light is freely controllable.

[0045]Since DMD26 can control the direction of catoptric light freely as aforementioned, Light flux required for image display is reflected toward the projection lens 27 the red irradiated from the microlens array 4, and among each green and blue light flux, and the light flux which is not required for image display is reflected toward the optical absorber 29. Image formation of the beam of light for every pixel reflected by each micro mirror 32 is carried out on the screen 28 with the projection lens 27. As shown in drawing 9, extended projection of the picture formed on a screen by DMD26 in the whole is carried out on the screen 28 with the projection lens 27. On the other hand, the light flux reflected toward the optical absorber 29 is absorbed, without being scattered about by the optical absorber 29.

[0046]It is condensed by the microlens array 4 and made to irradiate with the red reflected by the dichroic mirrors 24R, 24G, and 24B and each green and blue parallel beam toward the micro mirror 32 of DMD26 in the reflection type picture display device of this embodiment altogether. At this embodiment, the utilization efficiency of light is raised by entering the micro mirror 32 100%, without making the total luminous flux which condensed by the microlens array 4 advance into the crevice between the micro mirrors 32. After the light which advanced into the crevice between said micro mirrors 32 carries out scattered reflection within said crevice, since the problem which soils the projection picture on the screen 28 by carrying out the stray light in the direction of the projection lens 27 is not generated, either, a beautiful display image is obtained.

[0047]However, in such a reflection type picture display device, when the conventional microlens array substrate 40 of the structure shown in drawing 16 is used, there are the following problems. That is, since the focal distance of each lens of the microlens array 42 is equal, in drawing 21, the light flux which penetrated each lens is converged in respect of being parallel to the microlens array substrate 40, respectively (K1, K2, and K3). In such a case, since the distance Q1 of each focus K1, K2, and K3 and each corresponding DMD26 and Q2 differ from Q3, respectively, All the light flux which makes the back projection lens 27 which stops having corresponded, and was reflected in DMD26 penetrate cannot be completed on the screen 28. [optical distance's from the focus K1, K2, and K3 to the screen 28] As a result, small-fire injury generating was not able to be carried out at the image projected on the screen 28, and a clear picture was not able to be acquired. Although only green light flux is illustrated in drawing 21, the same may be said of red light flux and blue light flux.

[0048]Since each lens can be formed with different arbitrary curvature if the microlens array substrate 1 of this invention is used, the focus of each lens can be arranged on the field 37 parallel to DMD26 (drawing 12). In this way, if the focus S1 of each lens of the microlens array substrate 1, S2, and S3 grade are made to agree on the field 37 parallel to DMD26, The optical distance from each focus to a screen becomes equal, and a clear picture can be acquired by completing all the light flux which makes the back projection lens 27 reflected in DMD26 penetrate on the screen 28. Signs that it is reflected by the micro mirror 32 of DMD26 toward the projection lens 27 emitting once it is completed with the focus of each lens by each light flux condensed with each lens of the microlens array substrate 1 of this invention are shown in drawing 12. Then, a bright clear display image can be obtained by what you condense again and is made to converge on the screen 28 with the projection lens 27 as mentioned above (not shown).

[0049]In drawing 12, although only the green parallel beam reflected from the dichroic mirror 24G of

drawing 10 was illustrated, as the red parallel beam R and the blue parallel beam B are also hereafter shown in drawing 13, it is the same. Drawing 13 is entered and completed in the direction to which the angle inclined to the direction of movement of the green parallel beam G only in 2 theta and −2 theta for the red parallel beam R and the blue parallel beam B (refer to drawing 10) by each lens of the microlens array 4. If the focal position of every light flux R, G, and B where these colors differ also uses the difference in the focal distance by the difference in the wavelength of the light flux of each color (chromatic aberration), it can become parallel to DMD26.
[0050](A 2nd embodiment) Drawing 14 is a schematic diagram showing the composition of the reflection type picture display device 28 by another embodiment of this invention. If it is in DMD26 used in this embodiment, many micro mirrors 32 are arranged on the concave curve, and each micro mirror 32 is also constituted by the concave mirror or the convex mirror. A deer is carried out and extended projection of the picture of DMD26 is carried out on a screen with the concave mirror formed of the DMD26 whole (set of the micro mirror 32).
[0051]Each micro mirror 32 is having the focal distance designed carry out image formation of the light flux of each color which entered into the micro mirror 32 on a screen. That is, it is condensed with each lens of the microlens array 4, and when entering into the micro mirror 32 and reflecting by the micro mirror 32, emitting slightly, it converges by the micro mirror 32 and image formation of the once convergent light flux is carried out on a screen.
[0052]Therefore, a clear picture can be acquired in this embodiment, without using a projection lens. What is necessary is just to set the focus of each lens as the middle point with each micro mirror 32 corresponding to each lens of the microlens array 4, and each lens of DMD26 at this time. This is because the spot diameter of each light flux irradiated by each micro mirror 32 of DMD26 can be arranged. What is necessary is just to set up the curvature of each micro mirror 32 according to the spot diameter of each light flux with which the screen 28 is irradiated.
[0053]What has arranged many micro mirrors 26 on a convex surface as shown in drawing 15 (a) may be sufficient as DMD26 used here. As shown in drawing 15 (b), DMD26 which arranged many micro mirrors 26 may be used on a three-dimensional curved surface.
[0054]By thus, the thing for which the curvature of each lens of the microlens array 4 is arbitrarily changed when manufacturing a reflection type graphic display device for the microlens array 4 combining DMD26 according to this invention. A focal position can be doubled with the 32nd page of the micro mirror of DMD26 arranged arbitrarily.

[Translation done.]